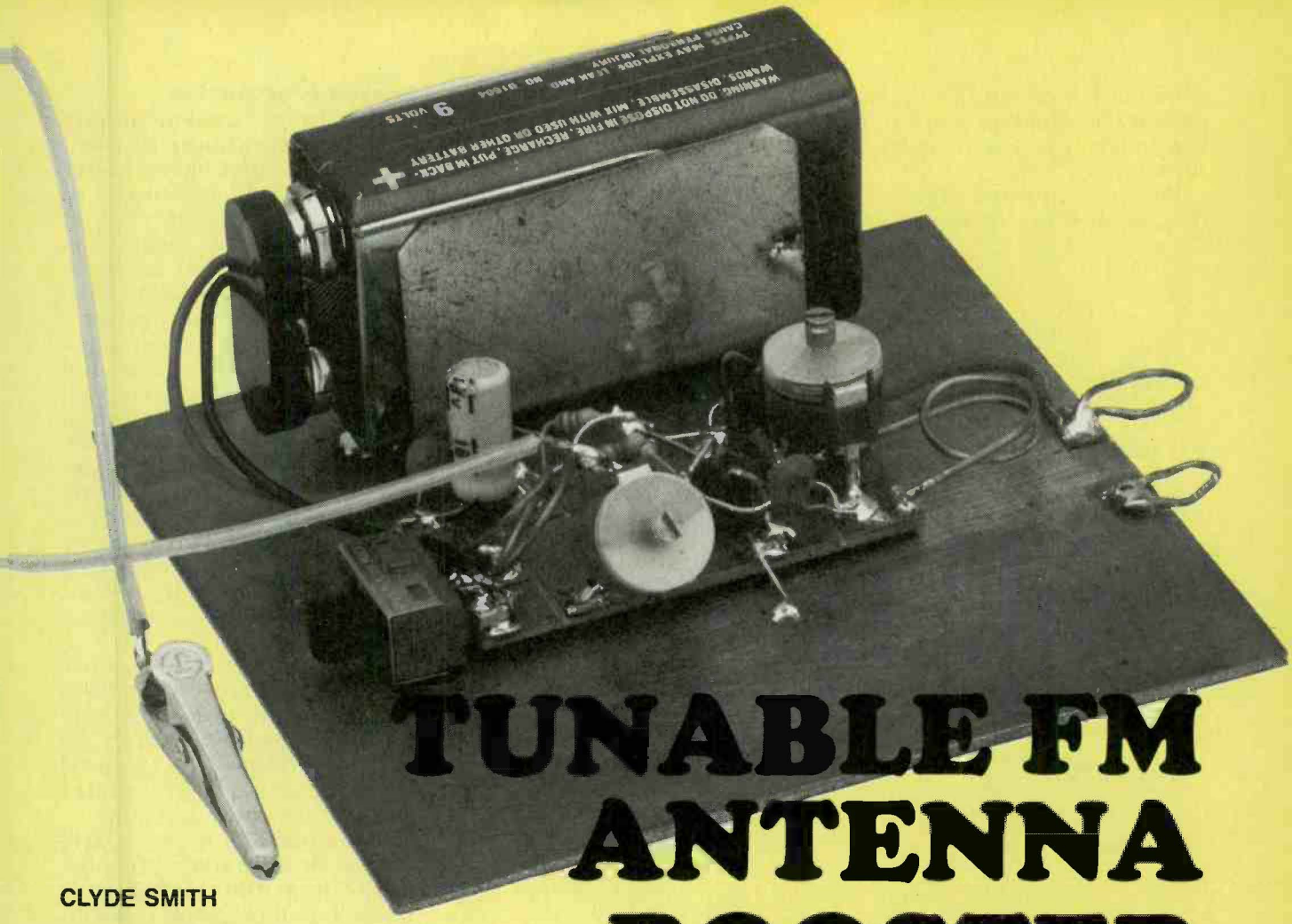

TUNABLE FM ANTENNA BOOSTER

CLYDE SMITH

Build this FM booster and enjoy broadcasts from distant FM stations that you've never been able to receive.

HAVE YOU EVER HAD DIFFICULTIES in picking up or holding on to distant FM stations that were broadcasting programs you wanted to hear? Or maybe you know there are more distant stations out there that are beyond the range of your receiver. You could, of course, buy or build a better FM tuner. However, by building a tunable FM booster you will both save money and dramatically expand your FM listening reach.

It's true that factory-made FM boosters are available from electronics stores and mail-order houses, but they can cost as much as $50. By contrast, the parts for our FM booster cost less than half that amount. The project should take only a few hours to complete, and you have many options for packaging the two-stage amplifier circuit.

You'll be amazed at the gain of this little circuit. The prototype has picked up stations more than 150 miles from the receiver! You'll need an indoor rabbit-ear antenna as shown in Fig. 1. The antenna is connected to the input side of the booster, and the boosted signal is sent via a single wire to the retracted antenna of the FM radio. Some simple adjustment procedures will be required after you hook up the circuit.

This FM booster improves selectivity when it is precisely tuned to a desired station that is close to others in frequency—a feature not found in broadband units. This selectivity is especially important for battery-powered, portable, Walkman-type receivers or low-performance FM receivers. This circuit also boosts weak signals to a stereo lock-on level. However, when you are listening to strong local stations, you'll want to switch the booster off to prevent audio "swamping."

Circuit description

The booster circuit, whose schematic is shown in Fig. 2, is a two-stage radio-frequency amplifier. It includes two 2N3904 NPN transistors, Q1 and Q2, capable of 250-MHz operation. The signal from the rabbit-ears is fed to the first stage at the base of Q1, which is biased for optimum gain by R1. The circuit is tuned to the incoming signal frequency by the

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combination of coil L1 and capacitor C1, which is coupled to the collector of the transistor through C3.

The preamplified signal is then applied to the base of Q2 through C4. The components in the second stage are identical to those in the first stage, and its frequency is determined by L2-C2 in the collector circuit. The fully amplified RF signal is then fed to the antenna of the FM receiver from the junction of L2-C2 with an insulated wire about 8 inches long terminated with an alligator clip. If the FM receiver has a telescoping antenna, collapse it to its retracted position.

The tunable FM booster is powered by a standard 9-volt transistor battery through switch S1. Capacitors C6 and C7 across the battery input perform filtering and stabilization on the power supply.

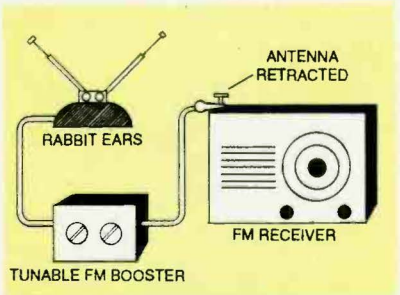

FIG. 1—TUNABLE FM BOOSTER is connected between rabbit ears and retracted antenna of FM receiver.

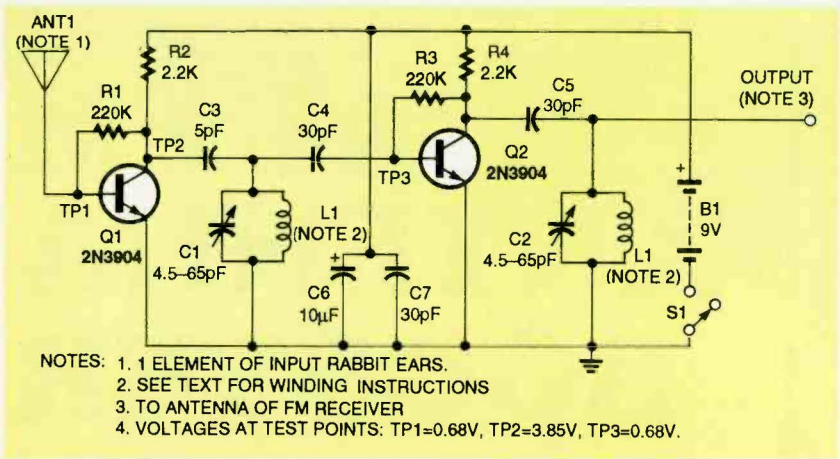

FIG. 2—TWO-TRANSISTOR AMPLIFIER CIRCUIT with tunable tank circuits boosts the distant FM signals.

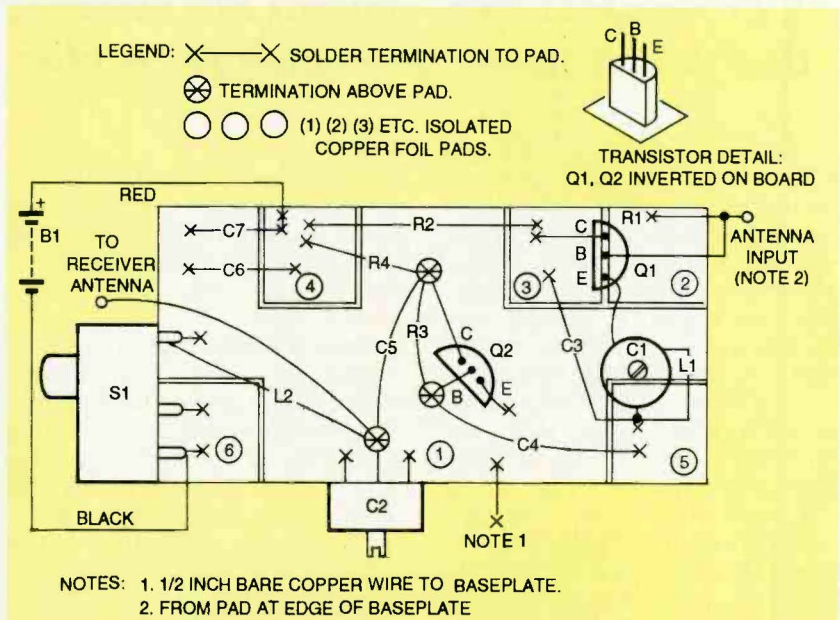

FIG. 3—PARTS PLACEMENT DIAGRAM. Components are soldered to pads on copper-clad board. Notice that the transistors are inverted.

Booster construction

The circuit components are mounted on a copper foil-clad, 0.040-inch thick, glass-epoxy circuit board, as shown in parts-placement diagram Fig. 3. It is cut 1½×¾-inches. Six electrically isolated areas or pads are formed on the board for component mounting by removing thin strips of copper down to the substrate around the pads.

This construction method permits the components to be soldered securely to the copper foil of the board without drilling any holes in the board. A finished circuit board can be obtained from the source listed in the Parts List, but if you want to make your own, a foil pattern is included here.

Two hand-wound, air-core coils, L1 and L2, are included in the circuit. To form each coil, wind a 2½-inch length of No. 20 AWG bare copper wire 1½ turns around a ⅜-inch diameter dowel or drill bit.

If you make your own board, remove the thin strips of copper foil to form the isolated pads with a handheld power tool with either a fine abrasive disk or circular saw in the tool chuck. You can also remove the copper manually by making parallel scores around the outlines of each pad with a sharp razor knife and carefully lifting out the thin strips between the scored lines.

Regardless of the method you use, inspect the fine channels with a magnifying glass and, with an ohmmeter, verify that there are no copper burrs between the isolated pads that could form an unwanted electrical path between them.

Position the leaded components as shown in parts placement diagram Fig. 3. The numbers on the diagram match the numbered pads on the circuit board. The "X" marks on the diagram indicate where lead terminations are to be soldered directly to the copper-foil pads, and the three stars indicate where lead terminations are to be soldered above the board, without making any contact with it.

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PARTS LIST

All resistors are ⅛-watt, 5% carbon film
R1, R3—220,000 ohm
R2, R4—2200 ohm
Capacitors
C1, C2—4.5 to 65 pF variable trimmer, Sprague-Goodman or equivalent.
C3—5 pF disc
C4, C5, C7— 30 pF
C6—10μF, aluminum electrolytic
Semiconductors
Q1, Q2—2N2904 NPN transistor (TO-92 package)
Other components
L1, L2—air core RF coils (see text)
S1 —miniature slide switch, SPDT
Miscellaneous: Rabbit-ear antenna with telescoping conductors, 1½ × 3-inch PC board (see text), 3 × 3-inch ground plane (see text), 3 miniature alligator clips, 9-volt battery clip assembly, insulated No. 22 AWG wire, bare No. 20 bare copper wire, 9-volt transistor battery, optional case, solder.
Note: The following items are available from Smith Kits, Route 2, Box 756, Salem MO 65560
- **Kit of all components and finished PC board except antenna, ground plane, and case—$19.95**
- **Finished PC board—$3.00**

Add $1.50 for shipping and handling. Missouri residents add local sales tax to all orders.

Notice that both transistors Q1 and Q2 are soldered in inverted positions. Solder the black and red leads from a 9-volt battery clip to the locations shown in Fig. 3. Cut an 8-inch length of insulated, stranded wire, trim the insulation from both ends, and solder one end to the junction of the leads from C2, C5, and L2.

After completing all soldering on the circuit assembly, check carefully at the points marked with the star to verify that no bare leads entering or leaving those junctions are in contact with any copper pads. Increase the spacing of the junctions above the board with a thin tool if they are too close to any copper pads.

Make a bracket for the 9-volt battery by cutting a 2½ × 1½-inch piece of tin-coated steel from a flattened can. File the edges to remove any sharp burrs, and file a slight radius on each sharp corner to round it off. Then bend up the ends of the metal up 90° along the dotted line to form a "U-" shaped channel. Leave a ⅝-inch spacing between the side pieces for inserting the battery.

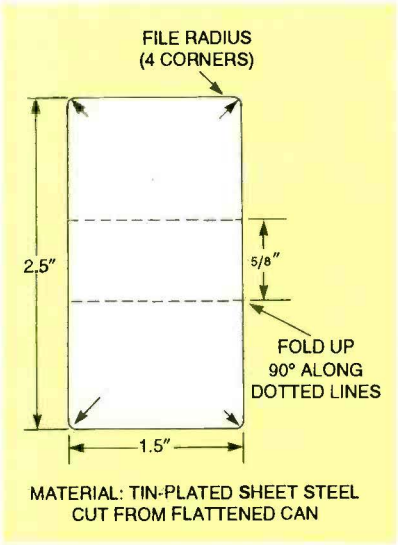

FIG. 4—PATTERN FOR BATTERY bracket cut from can metal.

Cut a second 3-inch square piece of copper foil-clad board for a ground plane, as shown in Fig. 5. Form an isolated ¼-inch copper foil pad with the method previously used along one edge of the board, as shown. Position the amplifier circuit assembly in a central position on the ground plane, and mark it with a pencil or felt-tip pen.

Solder the battery-mounting bracket to the 3 × 3-inch board adjacent to the circuit board "footprint" with solder beads at each end of the bracket channel. Then position the circuit assembly on the ground plane and solder a bare copper wire jumper from pad No. 1 on the circuit assembly to the plane, as shown in Fig. 5.

Form two loops from about 1-inch lengths of bare copper wire. Then solder a 1½-inch length of insulated, tinned cop-

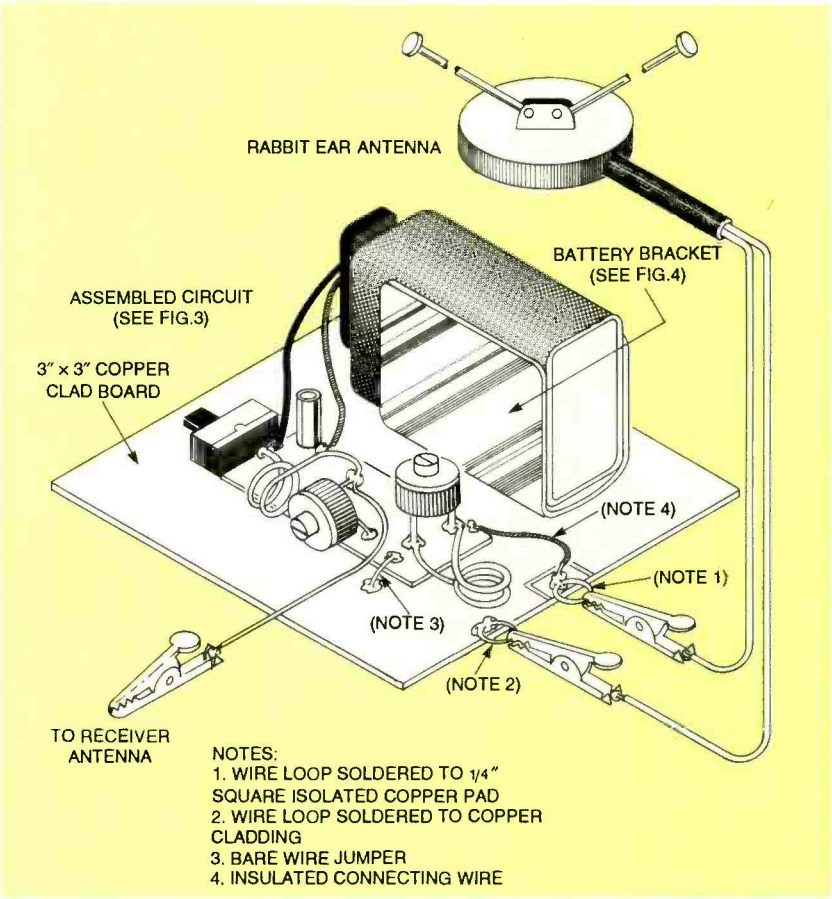

FIG. 5—BOOSTER ASSEMBLY DIAGRAM: 3 × 3-inch copper-clad ground-plane board holds a second board on which all components are mounted.

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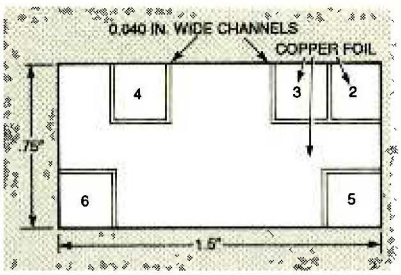
per wire from pad No. 2 on the circuit board to the pad on the edge of the ground plane while simultaneously soldering one of the copper loops to the pad. Then solder the second copper loop to a location adjacent to the pad, as shown in Fig. 5.

Solder miniature alligator clips to the terminations of the twin-lead from the rabbit-ear antenna, and solder an alligator clip to the end of the wire to the FM receiver antenna.

You might want to house the completed miniature circuit in a protective plastic case. Suitable project cases can be purchased from electronics stores or mail-order distributors that advertise in this magazine. If you put the circuit in a case, drill the holes for all external connecting wires and two access holes to tuning capacitors C1 and C2 before you position the assembly in the case.



CIRCUIT-BOARD FOIL PATTERN. Slits in the copper foil expose the insulating substrate.

The board can be fastened inside the case with beads of RTV silicone adhesive on the corners of the underside of the ground plane. You might also want to substitute small wire binding nuts and bolts for the wire loops on the ground plane for making the rabbit-ear antenna lead connections.

Be aware that the tunable feature of the booster increases gain, but it can also cause oscillation because the circuit is not neutralized. This drawback can be surmounted by placing and soldering circuit components precisely according to the parts placement diagram in Fig. 3 and closely following the adjustment procedures and any other suggestions that are given here.

Adjustment procedures

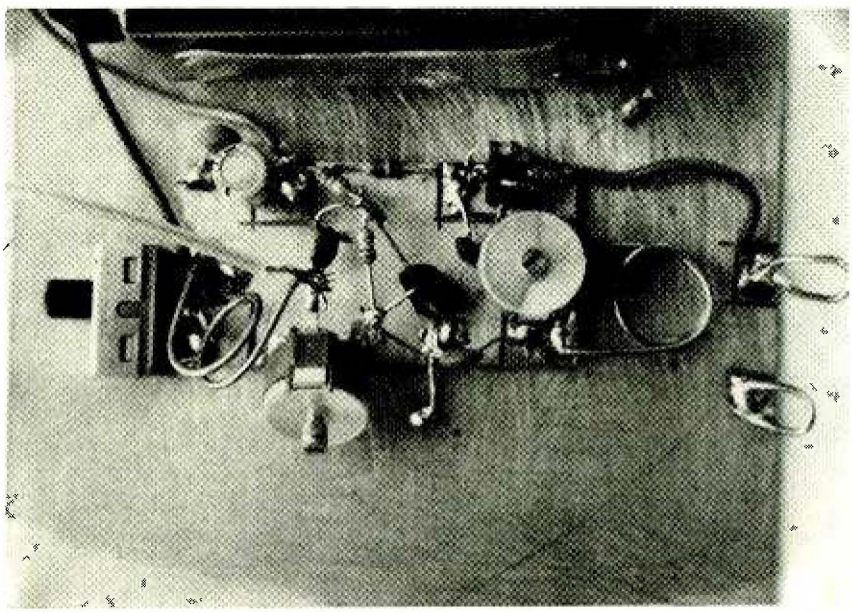
Perform the following adjustments:

1. Extend the rabbit ears to their limits, and position them with a separation angle of about 90°.
2. Connect the antenna leads to the 3×3-inch ground plane as shown in Fig. 5.
3. Switch the booster switch S1 OFF and the FM receiver's switch ON with its volume control set at a middle position.
4. Clip the alligator clip to the tip of the retracted antenna on the FM receiver, and tune to a station near midband that is barely audible. Avoid loud, overpowering local stations that will make the adjustment procedures more difficult than is necessary.
5. Adjust capacitors C1 and C2, and then orient the rabbit ears until you obtain maximum output from the selected station. If the station is broadcasting in stereo, the stereo indicator should indicate when signal strength is at its maximum.
6. Turn switch S1 ON, and if the booster is working properly, you should hear an increase in signal strength. If the circuit is not working properly, measure the voltage at the points shown on schematic Fig. 1 with a voltmeter, and compare the readings with those shown on the schematic.
7. If signal strength decreases, the amplifier might be oscillating or it might be mistuned. Adjust C1 and C2 very slowly to obtain the clearest signal; repositioning the antenna while observing the stereo indicator might also prove helpful in obtaining the most optimum signal possible.
8. Repeat the preceding steps for each FM station of interest. Once you adjust the booster for one position of the band, others within 10 to 20 MHz should be received as well. Some tweaking of C1 and C2 might be necessary to achieve this result. Be patient until you get the knack of maximizing gain—after some experimentation, you should get it right.

Adjustment suggestions

The receiver must be tuned exactly to the station frequency. However, if the desired results are not obtained, alternately shorten one rabbit ear dipole or the other while changing the orientation or angle between the elements.

If you use the booster with a portable receiver in a fixed location, clip the booster output lead to the earphone wire insulation near the jack. Be patient and this circuit will reward you with many hours of listening enjoyment. Ω



COMPLETED CIRCUIT ASSEMBLY mounted on the ground plane. The battery is at the top of the picture.

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